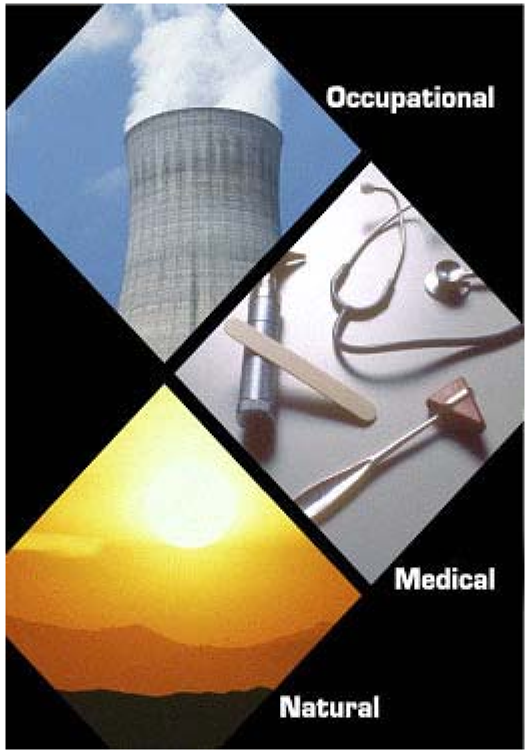
RADIATION
IN
PERSPECTIVE



The US Department of Energy
Assistant Secretary
for
Environment, Safety and Health
Office of Safety and Health

Ionizing Radiation and You

Ionizing radiation is a part of our environment and part of our lives. We regularly encounter it from both natural and man-made sources. In fact, humans and all other life on earth have evolved with routine exposure to the natural sources of radiation in our environment.

All animals and plants contain small amounts of naturally radioactive forms of carbon and potassium. Other natural sources of radiation include cosmic rays from outer space, and radioactive minerals and radon gas in our soil, water and air.

The Table below shows radiation exposures associated with some common activities (1 rem = 1,000 mrem). The "average" American receives about 360 millirem (or mrem – a measure of radiation dose) per year from all sources of radiation. This includes, on average 300 mrem from naturally occurring sources, and 60 mrem from man made sources and applications.

Source/Activity	*Average Dose/year (or as noted)*
5 hour jet plane ride	*3 mrem/5 hours*
Building materials	*4 mrem*
Chest X-ray	*8 mrem*
Cosmic	*30 mrem*
Soil	*35 mrem*
Internal to our body	*40 mrem*
Per Mammogram	*138 mrem*
Radon gas	*200 mrem*
Per CT Scan	*2500 mrem*
Per Cancer treatment	*5000 mrem*
Smoking 20 Cigarettes/day	*5300 mrem*

We use man-made sources and applications of ionizing radiation such as power plants, smoke-detectors, x-rays, C-T scans, and nuclear medicine procedures to improve our quality of life. Some persons receive occupational exposures as a result of their work or occupation – jet crews, nuclear plant operators, and medical staff, for instance.

Medical Application - a CT Scan in Progress

Why are we concerned about exposure to ionizing radiation?

Ionizing radiation consists of energy and particles that are given off by unstable atoms as part of a natural process to become stable. When we are exposed to such radiation – from the natural sources in our environment, from the work that we do, or as a result of medical necessity – there is a potential for biological damage to the cells and DNA (genetic material) of our body. In turn, such damage can potentially result in undesirable health effects – that is, there is a certain risk of illness (or even death) resulting from such exposure.

However, such risks are minimal at normal background radiation levels, at typical levels of medical exposure and at occupational exposure levels allowed by regulations. You can better understand the risks of exposure to ionizing radiation by putting them in perspective with other risks, and you can learn how to manage and reduce such risks.

Exposure limits and radiation protection programs

Government agencies have established regulations that set exposure limits for ionizing radiation, based on extensive scientific research and recommendations from national and international scientific organizations. These limits are designed to protect individual workers, the public, and the environment, and are set at "acceptable" levels of risk similar to those for industrial activities (e.g., chemical, mining, transportation).

The key U.S. limit for occupational exposure to ionizing radiation is 5000 mrem /year. Exposure to minors and the general public is set at 100 mrem/year. Medical exposures, however, are based on medical necessity, and are carefully calculated using standard methods. DOE radiation protection standards and exposure limits for workers are found in 10CFR835 (see http://tis.eh.doe.gov/whs/rhmwp/rule.html). The "DOE Occupational Radiation Exposure Report" (found at http://rems.eh.doe.gov/annual.htm) provides an annual analysis and explanation of observed trends in occupational exposure across DOE. The data is used to improve safety and to manage radiological safety programs with reduced risk.

Many organizations, such as DOE, require formal radiation protection programs to implement these regulations and help protect you. Such programs are managed by competent and experienced professionals and technicians, who track and control exposures, monitor radiological conditions, and manage radiological work through standards, procedures, training, and administrative and engineering controls.

What are the concerns and risks with exposure to ionizing radiation?

With exposure to ionizing radiation, there is a chance that cells can be damaged, and that DNA can be changed permanently, be impaired in function, or cease to function. Some forms of damage to DNA can lead to uncontrolled cell division, resulting in certain types of cancer. At low doses (e.g., background radiation levels), our bodies readily repair most cell and DNA damage. At very high doses, the body's repair mechanisms may be overwhelmed.

According to American Cancer Society, in the US, the chance of an individual contracting a fatal cancer from all causes (smoking, drugs, alcohol, pollution) is approximately 25 percent. [Risk can be expressed in many ways, for instance as the chance of something occurring (25%, 25 out of 100), or perhaps in terms of life shortening.] By example, if your cumulative occupational dose is 1000 millirem, the chance of eventually developing a fatal cancer can increase from 25 percent (as noted above) to 25.05 percent.

Most occupational exposures occur below the occupational exposure limit of 5000 mrem per year. At this level, the probability of increased health effects is very low – in other words, it is an acceptable risk to do beneficial work in exchange for the exposure. Exposures at high levels (where there can be immediate biological effects and more probable health risks) are infrequent and are considered abnormal occurrences. We base risk on the biological effects associated with the most likely types and levels of exposure.

While a routine medical exposure may increase the risk of cancer very slightly (on the order of nearly zero to a few percent), it must be balanced against the risk of not diagnosing a disease.

Risk can be evaluated based on total dose, or "dose equivalent". This is the sum of all radiation doses received by our body and its critical organs. The dose equivalent value can then be compared to a known dose (and risk) value, such as the average dose (300 mrem) received by a person in the United States per year from natural background radiation. For example, during 2001, average occupational exposures reported by DOE were 79 mrem, and 230 mrem by the NRC.

If a person is exposed to radiation from multiple sources, it is important to understand that radiation exposure (and the risk) is cumulative in nature, i.e., background + occupational + medical. In a case where you have medical and occupational exposures, the biological or health implications are cumulative or additive, so, you should work with your doctor and employer to manage your total dose equivalent to balance risks and benefits.

Reducing risk from ionizing radiation

In determining how increased radiation exposure can increase the chances of developing cancer (or of cancer death) over one's lifetime, there are several important considerations:

1. Radiation exposure has the same biological effects per unit of dose (rem) received in a year, regardless of the source of exposure, and is cumulative over a person's lifetime.

2. The scientific relationship between dose (exposure) and risk is not well understood at low levels of exposure. To ensure safety and aid in the regulatory limits, we conservatively assume that at low levels of exposure, cancer risk increases as dose increases, starting at the lowest exposure level (i.e. no threshold).

3. The risk of harm from radiation depends on the amount of dose, the dose delivery rate, the type of radiation, part of the body exposed, and the age and health of the exposed individual.

4. Radiation exposure is not the only thing that can increase cancer risk. Many other factors like ethnic origin, natural levels of cancers, diet, smoking, and stress affect the estimates of risk.

5. Risk from radiation exposure can't be directly measured, and is not distinguishable from the risk from other sources such as environmental, chemical, or biological.

6. Cancers that might develop from a radiation exposure usually have a latency period (a delay in showing up) of 2 to 10 years after the exposure.

The benefits associated with the use of ionizing radiation must be weighed against the risks to individuals and to society from this use. Each individual should control and manage their exposure from all sources of radiation to low levels to reduce the potential biological effects. We should always try to establish options where risks are "minimal" or "acceptable" to us. Some risks can be avoided by choosing not to participate in certain activities (e.g., sky diving). Remember, regulators have established the various ionizing radiation exposure limits at levels that reflect an acceptable risk when compared to the benefit received (e.g., electrical power, improved health), and when compared to the risk levels accepted for other similar activities (e.g., chemical industry, mining, driving, flying).

We can reduce our exposure and our risks in many ways, for example:

- Reduce exposure to radon gas by having your house tested and, if it is present, installing barriers or ventilation equipment to reduce the concentration of radon in living areas.

- Work with your doctor to control medical exposure. Use medical procedures involving radiation only when they are essential to diagnose an injury or illness.

- For clinically or medically required exposures, the benefit to the patient should outweigh the risk associated with the exposure.

- Employers should use innovative techniques, engineering controls, and administrative controls to keep occupational exposures "As Low as Reasonably Achievable" (ALARA).

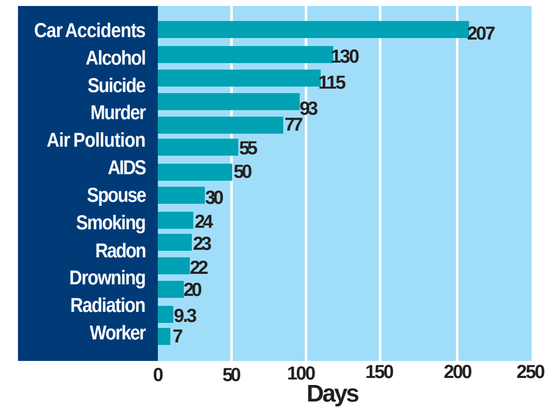
Risk perspective – it's relative!

There are things that ultimately result in many fatalities (e.g., driving, obesity and smoking), yet don't seem to concern us very much. On the other hand, some people are fearful of things (such as nuclear power plants), even though they don't result in deaths. Risk *assessment* is the objective view of a hazard – determining how a hazard really can affect us. Risk *perception* is the subjective view of a hazard – how we emotionally view it, our opinion of it, or how we feel about it. Risk-perception researchers have identified that natural risks concern us less. Also, people tend to accept risks with obvious benefits rather than risks imposed on them. If you have a basic understanding of hazards and the risks associated with them (risk-assessment capable), you can make intelligent decisions to manage them (establish a more realistic risk-perception). The chart below shows some of the common risks.

It is important to understand that the relative risks from radiation exposure can be compared to risks that we accept from non-radiological exposures and activities. Further, the health effects associated with low-level radiation exposures are not unique, and can be caused by a variety of other agents, including chemicals and disease. Still, radiation is often viewed as a more significant hazard. It is very useful to know what risks we are exposed to in our activities and how important each activity is to us.

With knowledge of the nature of ionizing radiation and its potential health effects, and how risk is expressed and managed, you are well on the way to being "risk informed" and taking an active role in managing your own safety and health concerns. You can help yourself establish a "risk assessment" that is on common grounds with your "risk perception."

Days of life lost:



References

The Health Physics Society Web Site at http://hps.org/publicinformation/ate/ is of special interest and an extensive "Ask the Experts" section answers questions related to medical, occupational, and natural aspects of ionizing radiation at http://hps.org/publicinformation/ate/cat5.html is very informative.

You can find more details, definitions, and explanations at the Web Sites listed below:

1. http://www.epa.gov/radiation/docs/risksandrealities/index.html
2. http://www.umich.edu/~radinfo/
3. http://www.medphysics.wisc.edu/~empw/ask1.html
4. http://www.iaea.org/worldatom/Press/Booklets/previous.shtml
5. http://www.umich.edu/~radinfo/introduction/risk.html
6. http://www.ncrp.com/
7. http://www.nih.gov/od/ors/ds/rsb/rsguide/
8. http://www.pantex.com/ds/pxrad001.htm
9. http://www.fda.gov/cdrh/radhealth.html
10. http://www.nrc.gov/what-we-do/radiation/about-radiation.html

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